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TNT Equivalency
Evaluation of Test Methods

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"TNT Equivalency is defined as the weight of a TNT hemisphere which provides the same free field peak overpressure, or ratio of impulse to distance at a given distance as produced by the material under test."[1] The method for determining TNT Equivalency of a given material has been standardized as outlined in DoD Explosives Hazard Classification Procedures TB 700-2, dated March 1981,[1] and in Structures To Resist the Effects of Accidental Explosion TM5-1300/NAVFAC P-397/AFM-88-22.[2] The two methods are basically similar.

A test specimen is placed at ground zero on a steel witness plate (fig. 1) in similar geometries and detonated with the aid of a booster in an explosive train. Airblast parameters (peak pressure, time of arrival, positive duration and impulses) are measured by piezoelectric or piezoresistive gages and then compared with standard hemispherical reference data.[3] This curve, which has been revised for more recent impulse data,[4] is currently being used as the reference by most experimenters.

The standardized test method requires, as minimum, a 20 kHz frequency response recording system. Modern state-of-the art measurement systems have an average frequency response of 500 kHz. Systems are obtainable for a nominal cost having frequency response of 2 MHz and systems up to 5 MHz are available. Thus, with the advancements in state-of-art equipment, it is now possible to achieve a higher degree accuracy with better resolution and greater precision than ever before. Stated another way, it is now possible to see the actual rise of the pressure-time profiles without sacrificing any other part of the pressure-time profile.

A study was conducted by McKown and Wilcox[5] using 20 kHz, 80 kHz and 500 kHz measurement systems. Their results are summarized in figure 2, which shows that frequency response can limit what is seen and reported. The measured value of the peak pressure increased with an increase in frequency

response. Similar results were also obtained by the author when calibrating a new instrumentation system using hemispherical-shaped composition C4 charges and comparing these values to another instrumentation system that had a frequency response of 20 kHz versus 500 kHz. The peak pressure values of the 20 kHz system were exactly one-half of the measured value of the 500 kHz system at the same scaled distance of 1.19 m/kg$^{1/3}$ (3.0 ft/lb$^{1/3}$).

Under the auspices of the Army Plant modernization program, airblast data were obtained on approximately 44 explosives, propellants, and pyrotechnic materials.(6) The majority of the explosive and propellant data were measured by 100 kHz and 500 kHz data acquisition systems. Generally the values reported were significantly greater than unity. Many of the materials tested were in in-process configurations of orthorhombic or cylindrical containers with varying aspect ratios (L/D) usually greater than or less than 1:1. The data were compared to the standard TNT hemispherical reference curve;(4) such a comparison would make the equivalency values for the test material seem high. The fact that the geometries are not always similar accounts for some of the differences.(7) Secondly, the sample material was placed on a steel witness plate providing for a standarized reflecting surface at point source; thus the incident and reflected wave would coalesce to yield higher pressure and impulse values(8) than if the surface at ground zero were a perfect absorber. Charge shapes such as orthorhombic and cylindrical also causes variances in the measurement due to edge effect.(9) Still, all of these factors cannot always account for higher-than predicted pressure and impulse values often noted in the experiments.

McKown conducted a study(10) using cast TNT hemispheres ranging from 8.16 to 9.53 kg (18 to 21 lb) in the same configurations outlined in TM5-1300. His results indicated that peak pressure values for cast TNT hemisphere were greater than unity at all scaled distances betwen 1.19 m/kg$^{1/3}$ (3.0 and 18.0 ft/lb$^{1/3}$). TNT equivalency values for hemispherical TNT varied from a minimum of 110 percent to a maximum of 157 percent when compared to the standard reference curve. In essence, the pressure curve shifted to the right for these scaled distances. Impulse values, however, did not follow exactly the same trends; at scaled distances of 2.14, 3.57 and 7.14 m/kg$^{1/3}$ (5.4, 9.0 and 18.0 ft/lb$^{1/3}$) impulse values were greater than unity (fig. 3). Although McKown's study was only preliminary (due to the limited number of tests), it is possible than using 500 kHz or greater measuring systems could

cause the reference curve for peak pressure values to shift to the right. Additional cast hemisphere tests are scheduled. The work to date is in no way intended to replace the current standard TNT hemisphere reference data, but rather to enhance and supplement it. Continued use of existing reference curves is warranted.

The data obtained for the Army Plant moderization program were reported for in-process configurations that represent real situations that include:

- Rigid reflecting surfaces
- Varied geometries representing small and large aspect ratios
- Bulk and/or cast material

Such configurations would yield higher values, which may represent "worst case" scenarios that do in fact account for large amounts of damage even in facilities originally designed to existing standard reference curves. What had not been taken into account previously was the fact that the data generated for the modernization program were obtained using modern state-of-the art measurement systems.

SUMMARY AND CONCLUSIONS

(1) There are standarized methods for determining TNT Equivalency.

(2) With modern measurement instrumentation, it is possible to be more precise in obtaining pressure and impulse values because of greater resolution and accuracy.

(3) Preliminary results of recent cast TNT hemispherical tests indicate that new peak pressure values versus scaled distances could shift the standard TNT reference curve to the right.

(4) Airblast parameters measured on 44 explosives, propellants, and pyrotechnics indicated higher peak pressure and impulse values, due primarily to geometries, reflecting surface, and state-of-the art instrumentation systems.

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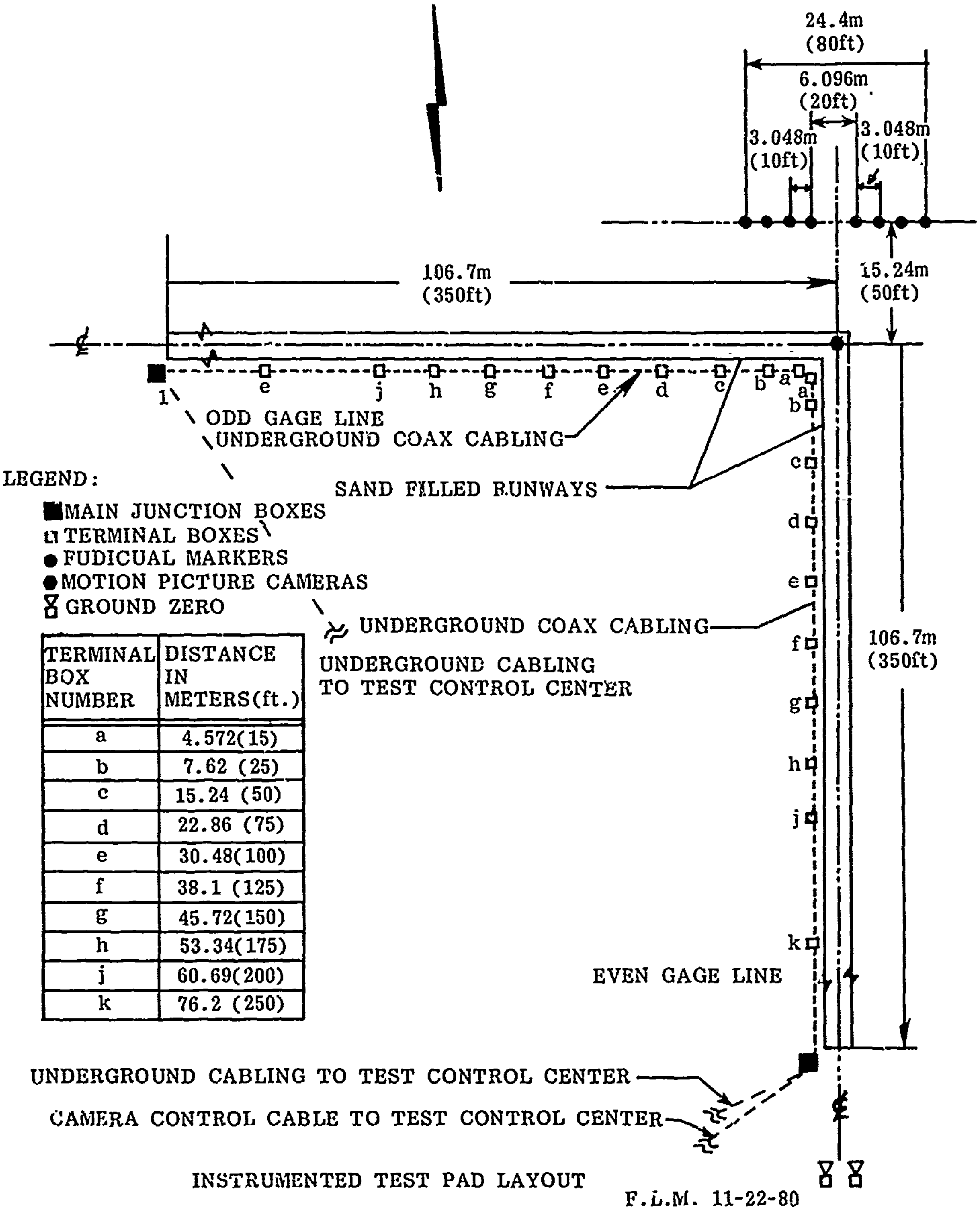

TERMINAL BOX NUMBER	DISTANCE IN METERS(ft.)
a	4.572(15)
b	7.62 (25)
c	15.24 (50)
d	22.86 (75)
e	30.48(100)
f	38.1 (125)
g	45.72(150)
h	53.34(175)
j	60.69(200)
k	76.2 (250)

INSTRUMENTED TEST PAD LAYOUT

Figure 1

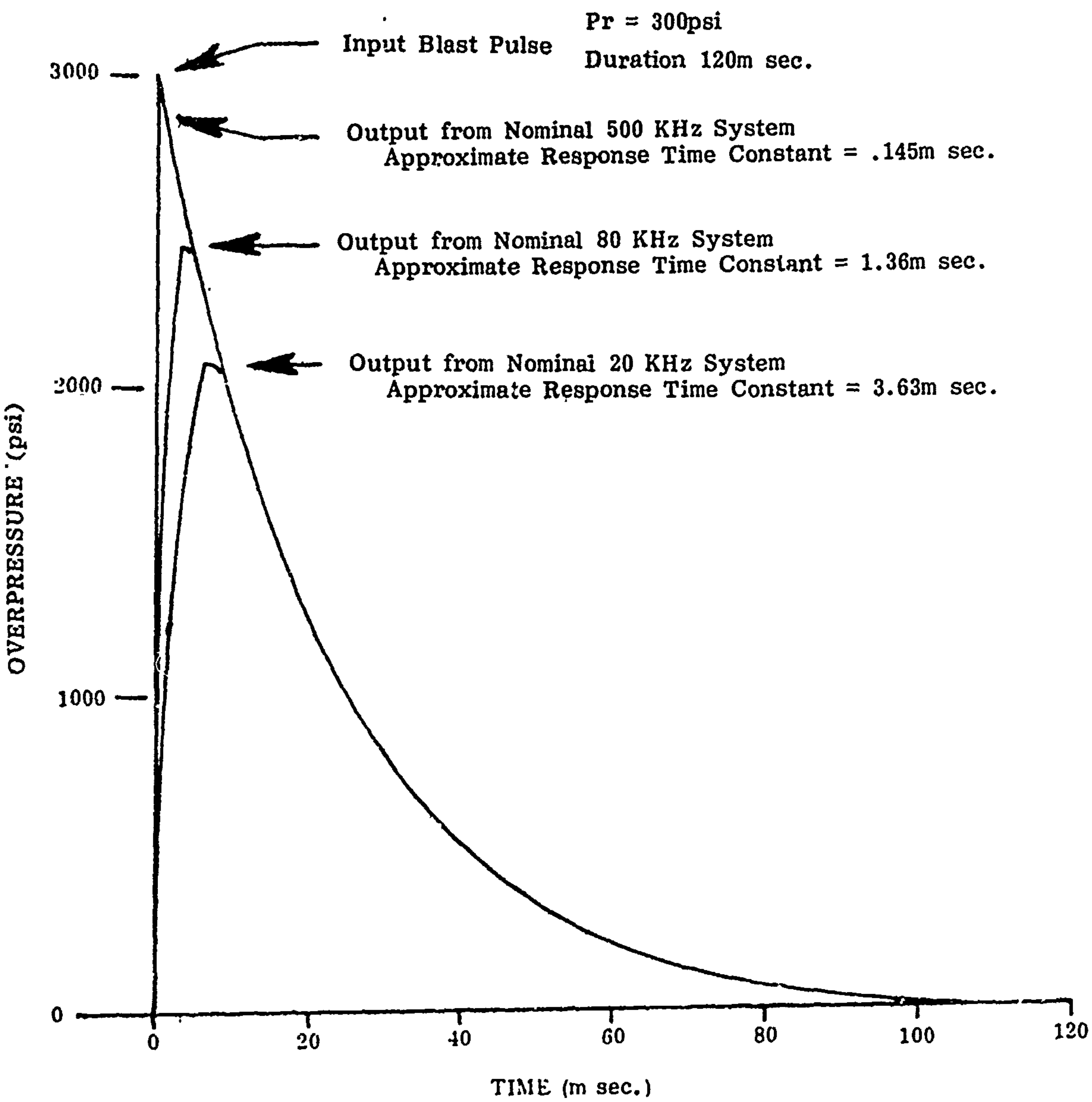

Figure 2. Data Processing System Output Versus Time Showing The Effects of System Frequency Response Limitation On A Typical Blast Pulse Input

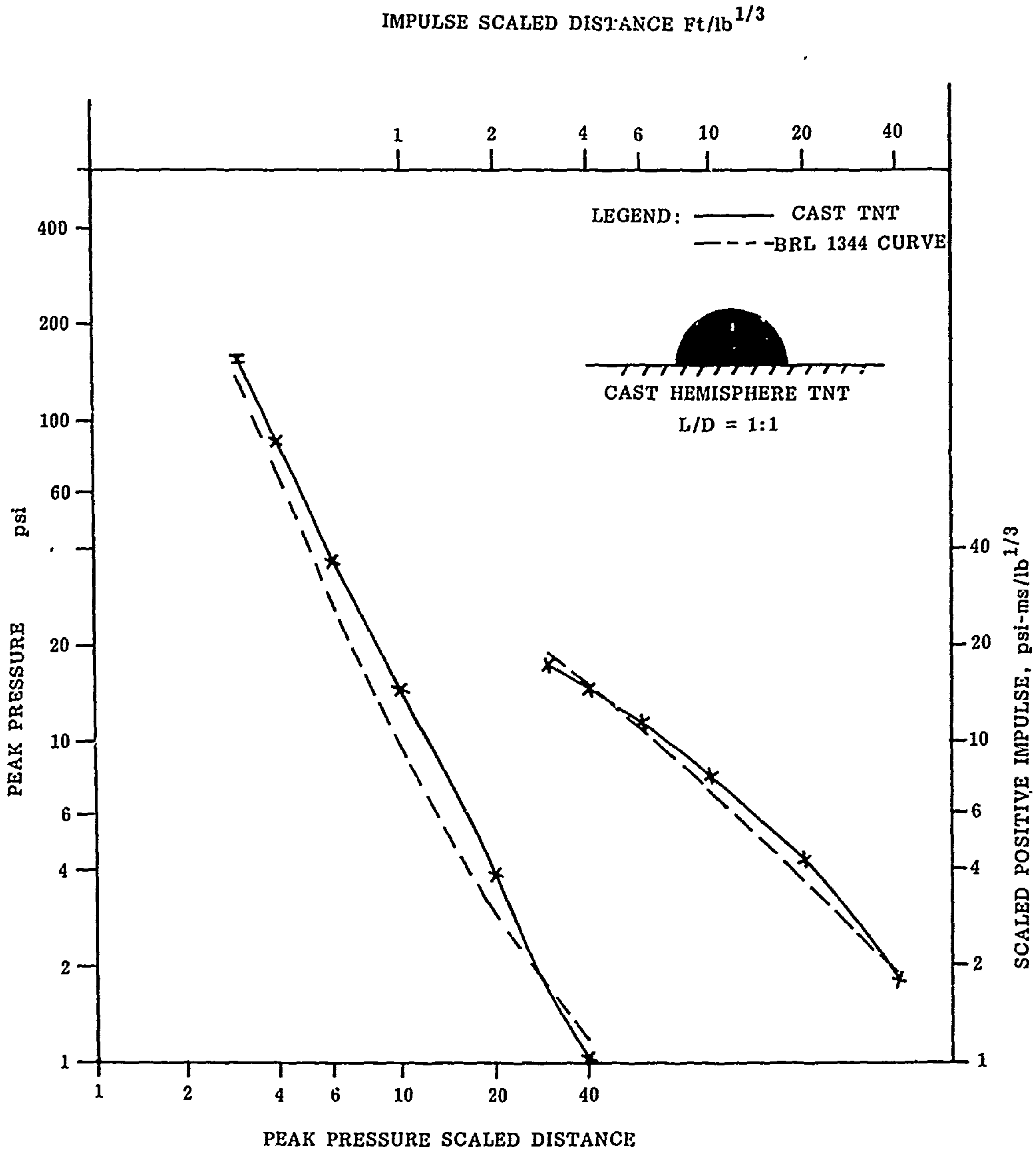

Figure 3. Peak Pressure And Scaled Positive Impulse Versus Scaled Distance For Cast TNT Hemisphere Compare To Standard Reference Curve (BRL-1344)